§31. Study on Mechanisms of Superconductivity Change by Neutron Irradiation

Kiss, T., Inoue, M. (Dept. of Electrical Eng., Kyushu Univ.),
Idemitsu, K. (Dept. of Appl. Quantum Phys. and Nuclear Eng., Kyushu Univ.),
Ochiai, K. (JAEA FNS),
Nishimura, A.

In the nuclear fusion reactor, superconducting magnet will be irradiated by fast neutron. Purpose of this study is to investigate the influence of such fast neutron irradiation on superconducting properties and explore its mechanism from the direct observation of fluxoids in mesoscopic scale. As the first year of this project, we also established a procedure to control and transfer irradiated samples to carry out detailed measurements.

We selected pure Nb thin plates as a sample in order to investigate in simple system. After rolling and annealing, we mount the sample on $SrTiO_3$ substrate and polish Nb surface. This process results in the thickness of the Nb plate about 300 μm. In order to change the grain size, we adopted two different annealing conditions, i.e., 800 Celsius,10 hours and 900 Celsius, 1 hour, respectively.

Trapped fluxoids in the Nb thin plate was measured by the scanning SQUID microscope. Sensor head of the magnetic microscope is shown in Fig. 1. SQUID sensor can detect flux passing through a small pick up coil with very high sensitivity. By scanning the sensor on the sample surface with a step distance of 1 or 2 μm, we obtained 2 dimensional high resolution magnetic field image on the sample surface. Cooling the sample in the external field of 2 μT, we obtained an image of trapped fluxoids in the sample as shown in Fig. 2. If we integrate each dotted square area, total flux shows good agreement with the theoretical value 2.07×10^{-15} Wb. The numbers of the fluxoids in the measured area also agrees with the value estimated from the applied external field. Furthermore, the field profile at single fluxoid shows good agreement with the theoretical calculation assuming monopole on the sample surface and the distance between the surface and the pick up coil is 2 μm as shown in Fig. 3. From detailed analysis of each fluxoid such as reproducibility of trapped position and temperature dependence, we can estimate the influence of defects on each pinning site. Namely, we can investigate pinning properties in mesoscopic scale by using each fluxoid as a probe.

By using Fusion Neutronics Source at Japan Atomic Energy Agency, we irradiate Nb thin plate samples with fast neutron with 14 MeV. To transfer the sample to Kyushu University (KU) for the measurements, we registered nuclide Nb_m^{92} to radiation controlled area at KU. After we received authorization for the radioisotope, measurements on the irradiated samples are now ongoing.

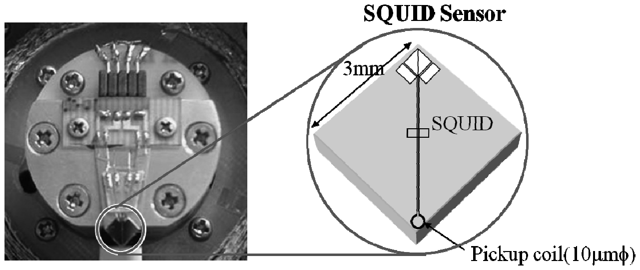

Fig. 1 Sensor head of scanning SQUID microscope. Nb based SQUID sensor is coupled with a 10 μm in diameter pick up coil and is mounted on a cantilever.

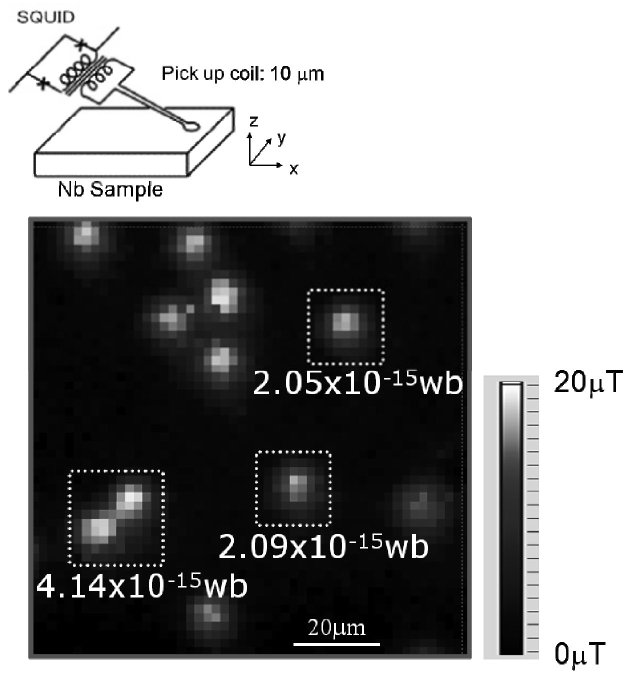

Fig. 2 Magnetic image of trapped fluxoids in Nb plate sample. Sample was field cooled with 2 μT of external field.

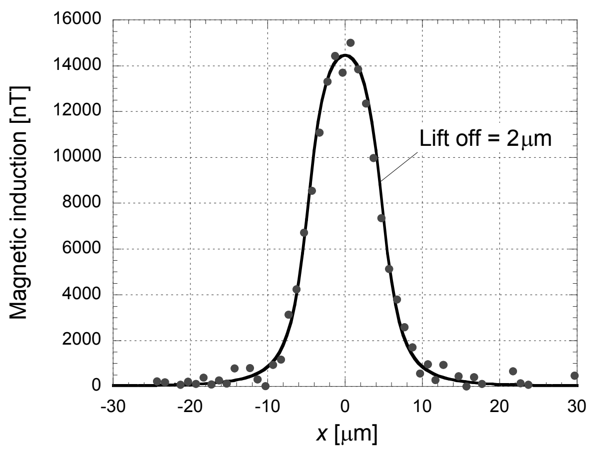

Fig. 3 Comparison with measurements (dots) and theoretical calculation (solid line) on the magnetic field profile. Distance between the pick up coil and the sample surface was estimated to be 2 μm.